U. S. ARMY TEST AND EVALUATION COMMAND
COMMON ENGINEERING TEST PROCEDURE

FIRE CONTROL ACCURACY TESTS WITH A DYNAMIC TESTER

1. OBJECTIVE

The objective of this MTP is to describe the use of the dynamic tester to evaluate the fire control accuracy of air defense systems.

2. BACKGROUND

To serve a useful purpose a weapon system must deliver accurate fire on the target. System accuracy measurements are prime test factors and probably the most difficult to obtain and analyze.

The most straightforward measurement technique is to actually fire the weapon at a typical target and note the results. This technique, however, yields accuracy data only for the particular conditions of the test. If this method is extended by firing numerous rounds at targets under various weapon and target conditions, test costs quickly soar to unjustifiable values and data are still only partially complete. Flight course simulation, using stored data based on various course parameters of many total flight paths, is a more versatile and economical method of evaluating and analyzing a weapon system. The devices that provide simulated target course parameters to the weapon system are called dynamic testers.

Dynamic testers measure the response of a weapon system or its major components under controlled input conditions, which have repeatability, without dependence on actual target aircraft, weapon firing, or elaborate data-gathering and data-reduction facilities.

With the dynamic tester laboratory type measurements of system tracking, computing, and other response characteristics are made under simulated target tracking conditions. An analysis of these response data along with the weapon-ammunition characteristics indicates the weapon system accuracy for any programmed weapon system-target condition. Limited firing tests with actual targets are used to confirm the laboratory analysis as well as to determine the effects of weapon vibration and human psychological factors on accuracy.

The tester compares the weapon system output parameters (usually azimuth, elevation, etc.) with the calculated correct response. The result is a record of the weapon system errors. The technique is compatible with a variety of data forms, scale factors, and weapon tracking rates. It is a versatile and effective tool for use in the analysis of weapon system performance. Effectiveness studies, including modeling in support of such studies formulate data requirements that can be supplied by dynamic testers.

3. REQUIRED EQUIPMENT

a. Dynamic tester consisting of four basic units:

1) A data storage group which is the storage medium for the information to be reproduced. This medium might be in the form of cams, metal, paper, or magnetic tape or memory cores.
2) A data conversion group which recalls the data from storage and converts it to a useful data form. The conversion group may vary in complexity from a directly positioned shaft or gear train to a complex analog or digital system.
3) A solution and comparison group which uses the programmed values from the data conversion group and computes theoretical values for the system responses. These values are then compared with those obtained from the system and a set of system error signals is produced. This group may be either an analog or digital computation unit plus the necessary logic circuitry.
4) An error recording group, analog or digital, which records the system error signals produced by the solution and comparison group. It may record additional information, such as theoretical values or system response values, if desired. This information is recorded as the test is conducted and is available for immediate analysis.

b. Accessory units which may be used with dynamic testers to extend their capabilities. Use of these units depends upon the type and purpose of the test and the method required for its implementation. Accessory units presently available are:

1) Data preparation units which convert computed target path parameters to a compatible format for use by the dynamic tester. These units enhance the versatility of the tester by permitting changes in the stored test program.
2) Angle tracking error and range insertion units for the radio frequency, intermediate frequency, and video signal stages. The IF and RF insertion units provide synthesis of target return variations with range and monopulse and rotating beam angle tracking errors. They therefore add flexibility to the basic dynamic tester by providing a facility for activating a complete weapon, including the radar, computer, and power control system, in a realistic manner.
3) Digital and analog recorders which can provide data in a format available for immediate analysis.

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13. ABSTRACT

Discusses a method for evaluation of fire control system accuracy. Describes pretest requirements for instrumentation and equipment, familiarization with dynamic tester, target course selection, weapon system-dynamic tester interface, preparation of data storage medium and connecting the tester. Provides procedures for tracker response and control with an operator, computer lead accuracy, tracker and computer accuracy with simulated operator, and system overall accuracy with a real operator. Limited to air defense systems.

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4. REFERENCES

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5. SCOPE

5.1 SUMMARY

This MTP discusses in general terms the steps involved in using dynamic testers to measure air defense system fire control accuracy. The following points are covered:

a. Preliminary action including:

1) Familiarization with the dynamic tester.
2) Selection of the target course.
3) Weapon system-dynamic tester interfacing.
4) Preparation of data storage medium.
5) Connecting the tester.

b. Test phases including evaluation of:

1) Tracking subsystem without an operator.
2) System computer.
3) Tracker-computer combination using a perfect or simulated operator.
4) Complete system using a real operator.

5.2 LIMITATIONS

This MTP is limited to general procedures because specific procedures depend upon the particular weapon system being tested and the dynamic tester being used.

6. PROCEDURES

6.1 PREPARATION FOR TEST

6.1.1 Familiarization With Dynamic Tester

Before conducting the test it is necessary to be familiar with the capabilities of the dynamic tester. Present dynamic testers can provide a number of independently variable parameters in the form of a shaft position, analog voltages, or digital representations. Various types of transducers (synchros, potentiometers, coders, and decoders) are used to convert or modify data for use with the weapon system under test. The number and types of transducers used depend on the input and output data forms of the weapon system and dynamic tester.

6.1.2 Target Course Selection

To thoroughly evaluate the fire control accuracy of an air defense system under dynamic conditions, many parameters must be measured over a range of conditions. For example, the maximum and minimum permissible angular displacements, velocities and accelerations; the maximum, minimum, and optimum firing ranges; and critical values of these and other parameters must be established prior to selecting the simulated course(s) to be used. Basic considerations in preparing synthetic courses are contained in reference 4.D. It may be desirable for the system to approach and attempt to "pass through" the critical values of several parameters simultaneously to investigate their interaction. Again, it might be desirable to select a course causing critical values to occur independently, thus permitting an individual analysis of the effects of the parameters on system behavior. These decisions must be made and parameter requirements specified before a flight course can be selected.

A straight, level, and constant-velocity target flight course can be defined by the primary parameters of initial target altitude, range, azimuth, heading and velocity. All other parameters are dependent upon these, vary with time, and may be in any coordinate set as referenced to the weapon system. Tables showing derived values and relationships of each secondary parameter with a number of primary parameters are contained in reference 4.E. Use of these tables will greatly simplify selection of the correct flight course for testing a weapon system. Maneuvering courses are programmed as required.

6.1.3 Weapon System and Dynamic Tester Interfacing

Another requirement in planning the test is to establish the way in which the dynamic tester and weapon system will be interfaced. In some cases there may be only one approach available. In other cases several alternatives may be possible, and the chosen approach will depend upon the type of data to be generated, the test objectives, the accessibility or availability of input points, or on economic factors.

Each type of weapon system will require study to fully define input, output, and intermediate parameters. The scale factors and range of values of these parameters must also be determined.

The interfacing must be done in a way that allows the required data to be obtained but does not interfere with the intermediate functions of the weapon system or change its overall performance characteristics.

6.1.4 Preparation of Data Storage Medium

Each type of dynamic tester employs specific procedures for preparing the data storage medium. Reference should be made to the literature covering the specific tester to be used.

6.1.5 Connecting the Dynamic Tester

The tester is connected electrically to the input of the weapon system receiver, computer, or other signal input point. The solution section of the tester is connected electrically to the output of the desired subsystem, to the weapon itself, or both, as applicable for the test. The stimulus supplied by the tester is applied as early as the fire control circuitry in possible to enable exercising the gun system to the maximum.

6.2 TEST CONDUCT

The test will consist of exercising the weapon system with the preselected target courses that have been programmed into the data storage section of the tester. The test may be divided into the following four phases, using test methods indicated in the operating literature for the tester.

6.2.1 Evaluation of Tracker

First the tracking subsystem is evaluated without an operator, to determine its response and control limitations. It may not be possible to perform this evaluation if an operator is essential to tracker functioning; it may nevertheless be possible to test and define the limits of intermediate tracker functions such as target ranging and response to angle control stimuli.

6.2.2 Evaluation of Computer

The next phase is to check the system lead computing accuracy. Performance of this test should be possible regardless of the system, although the information used as the input and output may vary with the type of system under test.

6.2.3 Evaluation of Tracker and Computer With Simulated Operator

The tracker and computer are tested in combination using a perfect or simulated operator. This eliminates the operator error factor in the

evaluation of system accuracy. Again, if an operator is required for the tracker, a complete test may not be possible; but it should be possible to evaluate intermediate operations and determine their limitations.

6.2.4 Evaluation of Complete System

Finally, the complete system is evaluated using a real operator. This determines the overall accuracy of the system when the human element is added. Additionally, if defines limitations on the system caused by a human operator and assesses operator performance.

6.3 TEST DATA

The data to be taken are determined by studying the system to be tested and the test objectives. This is done during the target course selection and tester-system interfacing steps. The data are obtained by the dynamic tester as the test is conducted and are available for analysis from the error recording section on a real time basis.

6.4 DATA REDUCTION AND PRESENTATION

The approach chosen to reduce the test results in light of their significance will depend upon the purpose of the test. Since the dynamic tester, when used as a development or maintenance support item, has many applications, data reduction in this MTP is discussed only in terms of the "end result" of dynamic testing. For engineering test purposes, the end result of a dynamic test is to establish the relationship between the solution developed by the weapon system and the theoretically correct solution.

The final format of the data is also determined by the test objectives and the particular weapon system. Examples of data that can be plotted are: errors in firing azimuth, ΔFa, and quadrant elevation, ΔQe, for individual courses, averages of ΔFa and ΔQe for each course; mean errors during the optimum firing interval; and intermediate functions, such as errors in range or range rate. These quantities may be plotted against various target or weapon system parameters such as time, target range, target velocity, system angular acceleration, and theoretically correct lead angle.